

**Biological Evaluation of  
Hemlock Stands in the Marlinton Ranger District for the  
Augmentative Release of *Laricobius nigrinus***

**Monongahela National Forest, West Virginia**

Prepared by

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## ABSTRACT

In the fall of 2005, personnel from the USDA Forest Service Monongahela National Forest (MNF) and the Northeastern Area State and Private Forestry Forest Health Protection program in Morgantown conducted hemlock woolly adelgid (*Adelges tsugae*) surveys in hemlock stands in the Marlinton Ranger District. The purpose of these surveys was to evaluate current adelgid population densities and find suitable sites for the augmentative field release of the native predatory beetle, *Laricobius nigrinus*. It is hoped that this and other release sites will serve as field insectaries for the collection and future dispersal of this predatory beetle to other areas of the MNF.

## INTRODUCTION

### Hemlock Woolly Adelgid

Adelgids are small, soft-bodied insects that feed on plant sap and have a complex life cycle. The family is divided into two genera: *Adelges* and *Pineus*. The members of this family feed exclusively on conifers. There are six species of *Adelges* in North America; only one, the Cooley spruce gall aphid, *Adelges cooleyi* (Gillette), is native (Montgomery 1999). This adelgid occurs coast to coast in Northern North America. Its primary hosts are recorded as white (*Picea glauca*), blue (*Picea pungens*), Sitka (*Picea sitchensis*), and Engelmann (*Picea engelmannii*) spruce (Baker 1972). It has an alternate host, Douglas fir (*Pseudotsuga menziesii*). There are 10 species of *Pineus* in North America, of which seven are native. Four of these (the pine bark adelgid, *Pineus strobi* (Hartzig); the pine leaf adelgid, *P. pinifoliae* (Fitch); the red spruce adelgid, *P. floccus* (Patch); and the spruce gall adelgid, *P. similes* (Gillette)) seem to be indigenous to Eastern North America (Drooz 1989, Montgomery 1999). These species attack eastern white pine (*Pinus strobus*), red spruce (*Picea rubens*), and black spruce (*Picea mariana*) but seldom cause extensive damage (Drooz 1989, Montgomery 1999). Little is known about the population dynamics, ecological role, or the predator and parasite complex associated with these native adelgids.

Native to Japan, the hemlock woolly adelgid is a serious pest of eastern hemlock (*Tsuga canadensis*) in the United States and a threat to Carolina hemlock (*T. caroliniana*) (Onken and others 1999). The latter tree species is found only in the southern region of the Appalachian Mountains (Onken and others 1999). The range of the adelgid is expanding rapidly each year; it is currently established in 16 Eastern States from Georgia to New Hampshire, and tree decline and mortality have increased at an accelerated rate since the late 1980s. In the Shenandoah National Park, hemlock crown health has declined drastically since the early 1990s. In 1990, greater than 77 percent of the hemlocks sampled were in a “healthy” condition; by 1999, less than 10 percent were in a “healthy” condition (Akerson and Hunt 1998). Hemlock health conditions have been monitored at the Delaware Water Gap National Recreation Area in Pennsylvania since 1993. As of 2005, nearly 25 percent of the hemlocks have died and virtually all of the remaining hemlocks are in moderate to severe decline (Onken, personal comm. 2006). Similar adelgid-caused impacts are also affecting most districts of the MNF.

The hemlock woolly adelgid is parthenogenetic (an all-female population with asexual reproduction); has six stages of development: the egg, four nymphal instars, and the adult; and produces two generations a year on hemlock. Each adult adelgid can produce between 50 and 300 eggs (McClure 1989, 1995). Natural mortality in adelgid populations is commonly between

30 and 60 percent (McClure 1989, 1996), but the reproduction potential remains high. Significant natural mortality is generally attributed to two likely causes: 1) an extended period of cold temperatures that coincides with a susceptible period of development for the adelgid, and/or 2) a sufficient loss in the nutritional quality of the food source, which is associated with the decline in health and vigor of the host tree (McClure 1996, Onken and others 1999). The adelgid feeds on plant fluids and can kill a mature tree in about 5 to 7 years depending on other environmental stresses (McClure and others 2001). This tiny insect (~ 1 mm) feeds on all age classes of hemlock, from seedling to mature, old-growth trees. Dispersal and movement of adelgids are associated with wind, birds, deer, and other forest-dwelling mammals, and humans move the adelgid during logging and recreational activities (McClure 1995). It has the potential to infest the entire range of eastern hemlock in the next 30 years. Natural enemies capable of maintaining low-level hemlock woolly adelgid populations are nonexistent in North America (Van Driesche and others 1996). Management of adelgid populations will require the establishment of biological control agents if we are to succeed at reducing their impacts on hemlocks in the forest environment (Onken and others 1999).

The hemlock woolly adelgid was first reported in the Western United States in the 1920s (McClure 2001). Adelgid populations on western tree species, including western hemlock (*Tsuga heterophylla*) and mountain hemlock (*T. mertensiana*), appear to be innocuous; these tree species are believed to be resistant because little damage has been reported (McClure 2001). In the East, the hemlock woolly adelgid was first reported in the 1950s near Richmond, VA. It was considered to be more of an urban landscape pest and was controlled with a variety of insecticides applied with ground-spraying equipment. Observations of the adelgid were periodically reported in several Mid-Atlantic States in the 1960s and 1970s but it was not until the 1980s that adelgid populations began to surge and spread northward to New England at an alarming rate. By the late 1980s to early 1990s, infestations of hemlock woolly adelgid were reported to be causing extensive hemlock decline and tree mortality in hemlock forests throughout the East (McClure 2001).

#### *Laricobius nigrinus*

*Laricobius nigrinus* Fender is a tiny (< 3 mm) Derodontidae beetle native to Western North America (Zilahi-Balogh and others 2002). It has been found in close association with hemlock woolly adelgid on western hemlock in British Columbia, Washington, Oregon, and Idaho where the adelgid is not considered a forestry pest (Zilahi-Balogh and others 2003). *L. nigrinus* was imported into Virginia from British Columbia, Canada, in 1998 and has since been screened in quarantine and evaluated to determine its suitability as a biocontrol agent for hemlock woolly adelgid in this country. Host suitability tests (tests that determine whether an agent can complete development and reproduce) and host acceptance tests (tests that determine whether an agent will feed or reproduce on a host) indicate that *L. nigrinus* will feed on other adelgid species, but can only completely develop and reproduce on hemlock woolly adelgid (Zilahi-Balogh and others 2002). Extensive laboratory and field tests in Virginia have demonstrated that *L. nigrinus* is an excellent natural enemy of hemlock woolly adelgid (Zilahi-Balogh and others 2002). In 2000, the USDA Animal and Plant Health Inspection Service (APHIS) issued Permit Number 48928 to Virginia Polytechnic Institute and State University to release *L. nigrinus* in Virginia. In 2003, the MNF participated in the initial field release of this beetle in the Marlinton Ranger District near Brushy Mountain (please see Forest Health Publication NA-03-15). Other releases occurred

concurrently within North Carolina, Pennsylvania, Maryland, and West Virginia. As a result, *L. nigrinus* was successfully established in North Carolina, Maryland, and Pennsylvania as of 2005.

*Laricobius* adults become active in the early months of the fall and feed on hemlock woolly adelgid nymphs all winter. In late January, they begin laying eggs in the ovisacs (wool sacs) of the adelgid, which continues through June. Eggs hatch 2 days after they are laid, and larvae develop through four larval instars, becoming more mobile as they mature (duration ~ 3 weeks). The mature larvae drop to the ground and pupate in the soil at the base of the tree, where they aestivate through the summer. The new generation of adults emerges from the soil in the early fall (Lamb 2003).

## OBJECTIVES

The objectives of this biological evaluation were to: 1) assess current hemlock woolly adelgid population densities within selected hemlock stands in the Marlinton Ranger District of the MNF, and 2) find suitable sites for the field release of the native predatory beetle, *L. nigrinus*.

## METHODS

Survey sites were selected using MNF stand data. Only stands with greater than 15 percent basal area in hemlock were identified as “hemlock.” A subset of those stands with road access was visited and evaluated. The guidelines used to evaluate current population density and stand suitability for predatory beetle release included: 1) stand access, 2) stand condition, 3) visual estimates of stand-level adelgid densities, and 4) visual estimates of individual-tree adelgid densities.

## RESULTS

One hundred and twenty-three stands were selected for evaluation. Only two stands (Compartment 55, Stand 27, and Compartment 653, Stand 001) met the criteria for predatory beetle release and are represented in figure 1. Hemlock woolly adelgid population levels ranged from light to moderate within these sites. Current adelgid populations are sufficiently high enough to support *L. nigrinus* populations.

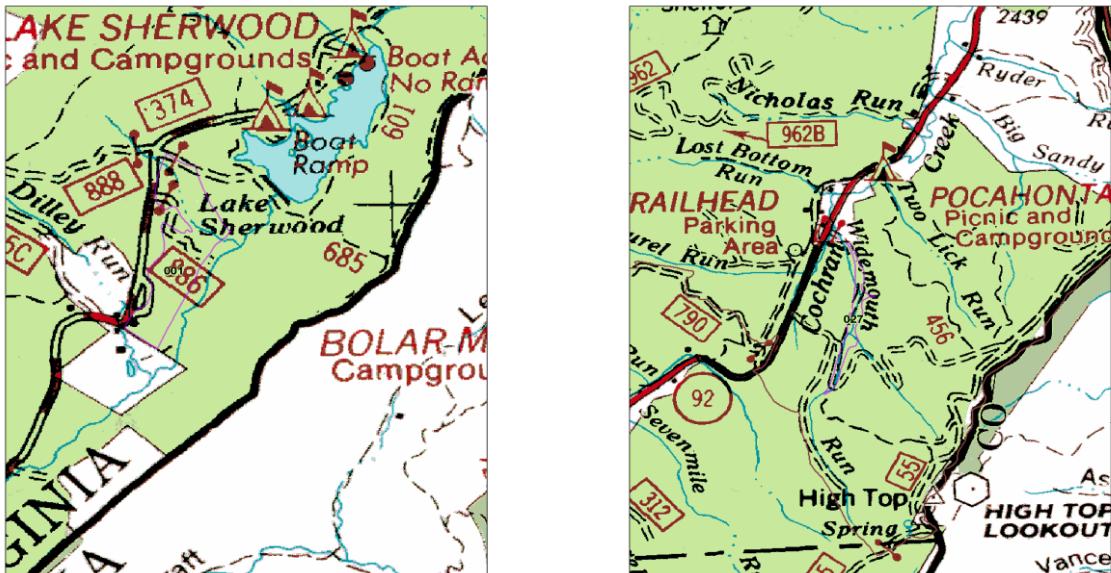


Figure 1. Proposed augmentative release sites (Compartment 55, Stand 27, and Compartment 653, Stand 001) for *L. nigrinus* on the Marlinton Ranger District of the Monongahela National Forest.

## ALTERNATIVES

For the selected hemlock stands in the Marlinton Ranger District, two management options have been evaluated. The augmentative release option was evaluated based upon the following objectives: 1) creating a field insectary for *L. nigrinus*, and 2) reducing hemlock woolly adelgid populations in infested stands. Each option is discussed below.

### Alternative 1: No Action

This alternative is considered the environmental baseline (the no action alternative). As a result, the previously released population of *L. nigrinus* would be allowed to establish and disperse to new areas. No natural barriers exist to limit the spread of this beetle on the MNF. However, it may take years or decades for the population to spread throughout the MNF. During that time, hemlock woolly adelgid populations would be allowed to increase and decrease naturally, without intervention, in eastern hemlock forests. In residential areas or where hemlocks grow near roads or trails that provide access for ground-spraying equipment, landowners will still have the option to chemically treat individual trees as needed to protect them. In the forest environment, however, there are no treatments available to minimize the impacts of tree decline and mortality caused by the hemlock woolly adelgid. Because the adelgid has a high reproductive capacity and has demonstrated the ability to rapidly spread in recent years, it is expected that adelgid populations will continue to increase throughout the currently infested area. This will accelerate their spread to currently noninfested areas. Population densities will likely fluctuate periodically depending on the severity of winters, but this would likely be localized within the more northern climates and be short in duration (1 to 2 years). Adelgid populations quickly rebound following such events, and consequently, impacts on hemlock resources throughout the range of eastern hemlock will likely increase as more hemlocks succumb to this pest.

## **Alternative 2: Augmentative Release of *Laricobius nigrinus* beetles**

The proposed action will involve the release of field-collected *L. nigrinus* in hemlock woolly adelgid-infested hemlock stands (figure 1) to accelerate the establishment and dispersal of this predatory beetle. The proposed releases would be conducted sometime in the spring of 2006 and consist of the release of up to 3,000 *L. nigrinus* beetles per site. Monitoring and evaluation efforts will continue after release to document beetle establishment and its potential for dispersal. USDA Forest Service Forest Health Protection entomologists will be providing a work plan with protocols to be followed for the project. The USDA Forest Service will be responsible for conducting the releases and monitoring both beetle establishment and the potential for dispersal. Additional releases of *L. nigrinus* beetles within these sites are possible in the future based on beetle availability and monitoring results.

## **RECOMMENDATIONS**

It is recommended that the MNF decide in favor of Alternative 2 (augmentative release of *L. nigrinus*) in the Marlinton Ranger District. Host acceptance tests have demonstrated that *L. nigrinus* will feed on nontarget adelgid species, and the possibility exists that these other adelgid species may be fed on. Land managers must balance the risk of nontarget effects with the potential benefits that come with control of the hemlock woolly adelgid. Augmentative release of *L. nigrinus* is expected to reduce the impact of the adelgid and may provide lasting and effective control in a cost-efficient manner. If some type of control is not implemented, the entire hemlock resource within the MNF could be severely impacted or lost in just a few decades.

## **ADDITIONAL INFORMATION**

### Could *L. nigrinus* impact other native predators or parasites that rely on hemlock woolly adelgid as a food source?

There are no known parasites of hemlock woolly adelgid in either this country or its country of origin. There are no other arthropod species listed as endangered or threatened at the Federal or State level that utilize the adelgid as a food source; hence, no such species will be affected by the release of *L. nigrinus*. The U.S. Fish and Wildlife Service concurs that there are no known federally listed threatened or endangered species that would be impacted by the release of this beetle (appendix A).

Of the native or introduced beetles found in natural hemlock habitat, none appear to be dependent on hemlock woolly adelgid and all have an alternate host preference. Beetle predators sometimes found associated with hemlock habitat include the twice stabbed lady beetle, *Chilocorus stigma* (Say), which preys on hemlock scales; the Halloween beetle, *Harmonia axyridis* (Pallas), which primarily feeds on aphids but will opportunistically feed on the adelgid; *Scymnus suturalis* (Thunberg), a common predator of the *Pineus* sp. that is occasionally found feeding on hemlock woolly adelgid; and *Laricobius rubidus* (LeConte), a derodontid beetle that feeds primarily on *Pineus strobi* on white pine but will also feed on hemlock woolly adelgid.

(Montgomery 1999). Brown lacewing, midge, and syrphid larvae have also been observed in association with the adelgid in Connecticut, but in low numbers (Montgomery 1999); these larvae are sometimes associated with egg masses of the hemlock woolly adelgid at low densities, but all are generalists and prey on mites, aphids, and other insect larvae (Cheah 1998). None of these predators, either individually or collectively, have a substantial impact on adelgid populations (Montgomery and Lyons 1996).

Could *L. nigrinus* become a nuisance to human habitations?

Behavioral studies indicate that *L. nigrinus* does not aggregate in large numbers prior to overwintering, as was the case with another nonindigenous lady beetle, *Harmonia axyridis*, which was introduced into the U.S. for biological control of aphids. *L. nigrinus* does not leave the forest to overwinter and observations suggest that this species hibernates in the leaf litter (Salom and others 2000). *L. nigrinus* has a narrow host range and, based on the work by Zilahi-Balogh and others (2002), was only able to complete its development on hemlock woolly adelgid. It is an adelgid specialist whose populations are expected to decrease as adelgid densities decline. In contrast, *H. axyridis*, a generalist predator, is able to maintain high densities by switching over to other, more abundant prey (Hennessey and McClure 1995).

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## APPENDIX A



### United States Department of the Interior

#### FISH AND WILDLIFE SERVICE

300 Westgate Center Drive  
Hadley, MA 01035-0589



In Reply Refer to:  
FWS/Region 5-TE

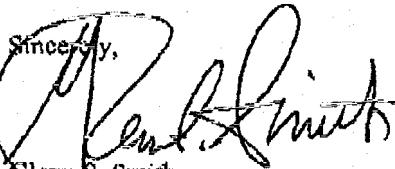
Mr. Bradley P. Onken  
United States Department of  
Agriculture Forest Service  
180 Canfield Street  
Morgantown, WV 2605-  
3101

Dear Brad:

This responds to your email correspondence of October 31, 2003, concerning the proposed introduction of *Laricobius nigrinus* (native to the northwestern United States), as a biological control agent for the hemlock woolly adelgid (*Adelges tsugae*) in infested hemlock stands in West Virginia, Pennsylvania and Maryland.

We have reviewed your recent correspondence and evaluated the related report and publication you provided. Given the results of the control tests that have been performed in relation to use of the *Laricobius nigrinus* as a HWA predator, there is no indication that these introductions will negatively impact any listed species or their habitat in these three states. Therefore, the Service concurs that this proposed action is not likely to adversely affect any federally listed, proposed, or candidate species or critical habitat, pursuant to the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). Therefore, no further ESA consultation is required at this time.

If any additional biological information resulting from the proposed action reveals any previously unanticipated impacts that may affect any listed, proposed or candidate species, please contact the Service to seek additional technical assistance and continued informal ESA consultation. Please contact me at 413-253-8627 if you have any questions or require further assistance regarding endangered, threatened or candidate species.

Sincerely,  
  
Glenn S. Smith  
Asst. Endangered Species Coordinator



State of West Virginia  
**DEPARTMENT OF AGRICULTURE**  
**Gus R. Douglass, Commissioner**

Janet L. Fisher  
Deputy Commissioner

Steve Hannah  
Deputy Commissioner

1/27/2006

Brad Onken, Entomologist  
USDA Forest Service  
180 Canfield Street  
Morgantown, WV 26505

Dear Brad,

Enclosed is your signed permit allowing the introduction and release of *Laricobius nigrinus* for the control of hemlock woolly adelgid. This matter of needing a permit to introduce a biocontrol agent may seem pretty lame, since other biocontrol agents have already been introduced and released without the required permit, but our Plant Pest Act does require that a permit be issued for the movement of insects (and plant pests) into and within West Virginia. In the past, this issue may have been either overlooked or maybe given a low priority. However, our regulations require a permit and I want things done correctly. Also, the information from the permit is kept in a data base here at Guthrie so we can check on what has been introduced and/or released. Even though the state permit data base is seriously lacking in information, we have a pretty good file on organisms introduced with federal permits.

Thanks for your cooperation and patience regarding this matter. The permit issued to you will be valid for five years. By that time maybe I'll be retired or we will have a better system in place.

Sincerely,

Gary W. Gibson, Director  
Plant Industries Division  
1900 Kanawha Boulevard, East  
Charleston, WV 25305-0191  
Office: (304) 558-2212 Fax: (304) 558-2435  
Email: [gibson@ag.state.wv.us](mailto:gibson@ag.state.wv.us)

Enclosure

According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information is 0570-0054. The time required to complete this information collection is estimated to average 0.17 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

FORM APP C  
OMB NO. 0570-0054

No permit can be issued to move live plant pests or noxious weeds until an application is received (7 CFR 330 (live plant pests) or 7 CFR 360 (noxious weeds)).

<b>U.S. DEPARTMENT OF AGRICULTURE</b> <b>ANIMAL AND PLANT HEALTH INSPECTION SERVICE</b> <b>PLANT PROTECTION AND QUARANTINE</b> <b>PERMITS AND RISK ASSESSMENT, UNIT 133</b> <b>RIVERDALE, MARYLAND 20737</b> <b>APPLICATION FOR PERMIT TO MOVE</b> <b>LIVE PLANT PESTS OR NOXIOUS WEEDS</b>		<b>SECTION A - TO BE COMPLETED BY THE APPLICANT</b>																																
<p>3. TYPE OF PEST TO BE MOVED</p> <p>* <input type="checkbox"/> Pathogens <input checked="" type="checkbox"/> Arthropods <input type="checkbox"/> Noxious Weeds  <input type="checkbox"/> Other (Specify) <i>bio control agent</i></p> <p>This permit does not authorize the introduction, importation, interstate movement, or release into the environment of any genetically engineered organisms or products.</p>																																		
<p>4. <i>Laniochines nigrinus</i> Derodentidae A</p>		<p>1. NAME, TITLE, AND ADDRESS (Include Zip Code)</p> <p><i>Brad Onken, Entomologist USDA Forest Service 180 Canfield Street Morgantown, WV 26505</i></p>																																
<p>5.</p>		<p>2. TELEPHONE NO. ( )</p>																																
<p>6.</p>		<table border="1"> <tr> <td>C. SCIENTIFIC NAMES OF PESTS TO BE MOVED</td> <td>D. CLASSIFICATION (Orders, Families, Genera, Species, or Strains)</td> <td>E. LIFE STATES, IF APPLICABLE</td> <td>F. NO. OF SPECIMENS OR UNITS</td> <td>G. SHIPPED FROM (Country or State)</td> <td>H. ARE PESTS ESTABLISHED IN U.S.?</td> <td>I. MAJOR HOST(S) OF PEST</td> </tr> <tr> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td></td> </tr> <tr> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td></td> </tr> <tr> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td></td> </tr> </table>					C. SCIENTIFIC NAMES OF PESTS TO BE MOVED	D. CLASSIFICATION (Orders, Families, Genera, Species, or Strains)	E. LIFE STATES, IF APPLICABLE	F. NO. OF SPECIMENS OR UNITS	G. SHIPPED FROM (Country or State)	H. ARE PESTS ESTABLISHED IN U.S.?	I. MAJOR HOST(S) OF PEST																					
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<p>7. WHAT HOST MATERIAL OR SUBSTITUTES WILL ACCOMPANY WHICH PESTS (Indicate by line number)</p> <p><i>None</i></p>																																		
<p>8. DESTINATION <i>National Forest &amp; other WV localities</i></p>		<p>9. PORT OF ARRIVAL <i>N/A</i></p>		<p>10. APPROXIMATE DATE OF ARRIVAL OR INTERSTATE MOVEMENT <i>2002 Feb thru March</i></p>																														
<p>11. NO. OF SHIPMENTS <i>10</i></p>		<p>12. SUPPLIER <i>OR State University</i></p>		<p>13. METHOD OF SHIPMENT <input checked="" type="checkbox"/> Air Mail <input type="checkbox"/> Air Freight <input type="checkbox"/> Baggage</p>																														
<p>14. INTENDED USE (Be specific, attach outline of intended research) <i>Establish hemlock woolly adelgid natural enemy complex in WV</i></p>																																		
<p>15. METHODS TO BE USED TO PREVENT PLANT PEST ESCAPE <i>N/A</i></p>		<p>16. METHOD OF FINAL DISPOSITION <i>First releases in infested hemlock stands</i></p>																																
<p>17. Applicant must be a resident of the U.S.A. <i>I agree to comply with the safeguards printed on the reverse of this form, and understand that a permit may be subject to other conditions specified in Section B and C.</i></p>																																		
<p>SIGNATURE OF APPLICANT (Must be person named in Item 1) <i>Brad Onken</i></p>																																		
<p>18. DATE <i>1/26/06</i></p>																																		
<p>WARNING: Any alteration, forgery, or unauthorized use of this document is subject to civil penalties of up to \$250,000 (7 U.S.C. §7734(b)) or punishable by imprisonment for not more than 5 years, or both (18 U.S.C. §1001).</p>																																		
<b>SECTION B - TO BE COMPLETED BY STATE OFFICIAL</b>																																		
<p>19. RECOMMENDATION <input checked="" type="checkbox"/> Concur <input type="checkbox"/> Disapprove <input type="checkbox"/> Accept USDA Decision</p>		<p>20. CONDITIONS RECOMMENDED</p>																																
<p>21. SIGNATURE <i>Say W. Glen</i></p>		<p>22. TITLE <i>Director, Plant Industry Division WV Department of Agriculture</i></p>		<p>23. STATE <i>WV</i></p>		<p>24. DATE <i>1-27-06</i></p>																												
<p>SECTION C - TO BE COMPLETED BY FEDERAL OFFICIAL</p>																																		
<p>25. PERMIT NO. <i>06-002</i></p>																																		
<b>PERMIT</b>																																		
<p>(Permit not valid unless signed by an authorized official of the Animal and Plant Health Inspection Service)</p>																																		
<p>Under authority of the Plant Protection Act of 2000, permission is hereby granted to the applicant named above to move the pests described, except as deleted, subject to the conditions stated on, or attached to this application. (See standard conditions on reverse side.)</p>																																		
<p>26. SIGNATURE OF PLANT PROTECTION AND QUARANTINE OFFICIAL</p>		<p>27. DATE</p>		<p>28. LABELS ISSUED</p>		<p>29. VALID UNTIL</p>																												
<p>30. PEST CATEGORIES</p>																																		

\* For exotic plant pathogens, attach a completed PPQ Form 526-1.

24. SIGNATURE OF PLANT PROTECTION AND QUARANTINE OFFICIAL      25. DATE      26. LABELS ISSUED      27. VALID UNTIL      28. PEST CATEGORIES

PPQ FORM 526 (OCT 2001)

Previous editions are obsolete.